Fortinet Universal Access Points
Deployment Guide

FAP-U421EV and FAP-U423EV

Fortinet Universal Access Points Deployment Guide

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About

This guide provides information on best practices to deploy FAP-U421EV and FAP-U423EV.

Audience

This guide is intended for network administrators configuring and maintaining the Fortinet Wireless LAN Systems. Familiarity with the following concepts is helpful when configuring the Fortinet Wireless LAN Systems:

- Network administration, including:
  - Internet Protocol (IP) addressing and routing
  - Dynamic Host Configuration Protocol (DHCP)
  - Configuring Layer 2 and Layer 3 switches (if required by your switch)
- IEEE 802.11 (Wi-Fi) concepts, including:
  - ESSIDs
  - Authentication Mechanisms
- Network Security (optional)
  - 802.1X
  - RADIUS
  - X.509 certificates

Related Publications

- ***FortiWLC (SD). Release Notes***

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Fortinet Universal Access Points

The FAP-U421EV and FAP-U423EV are dual-radio, dual-band 802.11ac Wave-2 access points that support one radio configured for 2.4 GHz operation and one radio configured for 5 GHz 11ac operation. The AP supports MCA (Multi-Channel architecture) deployment options, such as single-channel architecture (SCA), with or without Virtual Cell, SCA with channel layering, and MCA with ARRP (Auto Radio Resource Provisioning). The APs are designed to meet the requirements for even the most challenging deployment scenarios.

ARRP is disabled by default.

FAP-U421EV and FAP-U423EV Models

AP Model	Wireless	Wired	Antenna
FAP-U421EV	Dual Radio: 802.11ac/bgn - 4x4:4	2 interfaces: 10/100/1000	Internal
FAP-U423EV	Dual Radio: 802.11ac/bgn - 4x4:4	2 interfaces: 10/100/1000	External

The FAP-U421EV and U423EV radios include the following capabilities:

- Supports Universal Access
- Management from on-premise to cloud management
- 802.11ac Wave 2 technology with data rates of up to 2.2 Gbps
- 4x4 MU-MIMO (up to 4 streams) technology improves client throughput and range
- 802.11ac transmit beamforming (TxBF)
- Modulation up to 1024 QAM
- Integrated with Fortinet Security Fabric
- Virtual Cell enabled deployments segment traffic at RF layer

Default Radio Settings

- Interface 1 defaults to 2.4 GHz 11bgn (channel 6, 20 MHz width)
- Interface 2 defaults to 5 GHz 11ac (channel 36, 80 MHz width)

Ethernet Ports

- Supports two Gig-E ports, labeled LAN1 and LAN2
- Auto-negotiation supported
- LAN1 and LAN2 is the uplink port with PoE support.
- LACP supported.

Power

- 802.3at.
- 12v DC input

Deployment Considerations

802.11ac Deployment

The FAP-U421EV/U423EV are backward compatible with 802.11a/n and 802.11b/g/n clients, so you can upgrade your network today, and the existing client base will work with the new FAP U421EV/423. Fortinet provides solutions for both single-channel architecture (SCA) and multi-channel architecture, depending on the requirements for a particular customer's business and/or use case. Enterprises can add the FAP-U to their existing network to support additional capacity as part of their existing deployment. However, there are recommended best practices for operating a network that includes both 11n and 11ac APs. See the “Migrating to Wave2 FAP” chapter for more details.

WLAN Controller

Customers are required to upgrade the controller software, FortiWLC (SD) to version 8.2.0 or later to support the FAP-U421EV/U423EV.

FAPs support two data plane modes, bridged and tunneled. In bridged mode, also known as the remote AP mode, the data traffic from the client is bridged locally at the access layer or edge switch. Control and AP management traffic is still sent between the AP and the controller in bridged mode. In tunneled mode, all data, AP management, and control traffic is passed through the controller.

Clients per AP

The BYOD phenomenon has changed the enterprise network landscape and has forced IT managers to plan ahead for all types of user-owned mobile devices. BYOD typically means client densities are increasing, as it is not unusual for users to carry two or three WLAN-capable devices at a time. With BYOD, the client count per AP/radio has continued to rise, as one would expect. What follows are some general client density guidelines for the FAP-U421EV/U423EV.

- The maximum capability of the FAP-U421EV/U423EV is 128 clients per radio, or 256 clients per AP.
- The recommendation for a typical deployment is 30 clients per radio, or 60 clients per AP.
- The recommendation for high-density developments is up to 80 clients per radio, or 160 clients per AP.
- These recommendations for FAP-U421EV/U423EV are for both MCA and virtual Cell.

The actual number of clients recommended per radio depends on number and types of applications in use, SLAs, client types, etc. This subject is discussed in detail in the guide titled "BPG - High Density Design and Deployment," which is available for download through Customer Support.

Security Profiles

To ensure that you are benefiting from the VHT data rates available in 11ac, your security policies need to be configured to use WPA2 with AES-CCMP. The AES-CCMP requirement is part of the 11ac specification.

Signal Strength

The recommendation for 11n networks is typically that AP signal strength be -65 dBm or greater everywhere that Wi-Fi service is required for voice or video. This recommendation is influenced by the knowledge that 11n uses highest modulation rate of 64-QAM.

With 11ac, a higher signal strength is required to achieve the highest modulation rate of 1024-QAM. This is because 256 and 1024-QAM employs a much denser constellation than 64-QAM, which makes data corruption more likely at lower signal strength when using 256 and 1024-QAM. How much higher signal strength is required depends mainly on channel width. Wider channels will require higher signal strengths to achieve 1024-QAM rates.

For networks using 80 MHz channels, the widest channel width used in Wave 2 APs, a signal strength of approximately -51 dBm or greater is required to support 1024-QAM. For 40 MHz channels, a signal strength of approximately -54 dBm or greater is required to support 1024-QAM.

Modulation Scheme	40Mhz	80MHz
11n 64-QAM	-61	NA
11ac 256-QAM	-54dBm	-51dBm

SNR

Another important metric to consider when building a wireless network is the signal to noise ratio (SNR). With 11n networks, an SNR of 25 or greater is often recommended, particularly if voice and/or video applications are present. Although this recommendation still applies for 11n clients running on 11ac networks, for 11ac clients to achieve their highest possible data rates, the SNR should be approximately 32-36.

Switch and PoE Guidelines

In this section, we will provide recommendations for switching and PoE capabilities.

FAP-U421EV/U423EV

The recommendation is that each AP be connected via a single 1G Ethernet port, and that edge switches have a 10G uplink back to the distribution or core network switches. Following these recommendations will eliminate potential wired infrastructure bottlenecks.

Controller

As mentioned previously, if the data plane is configured for tunneled mode, a 10G uplink from the controller to the connecting switch is recommended, as all data plane traffic will need to

pass through the controller's Ethernet port/s. A 10G uplink can be used for bridged mode deployments as well, but since all data plane traffic avoids passing through the controller's Ethernet port/s, a 1G controller uplink port will most often be more than adequate for bridged mode deployments.

PoE

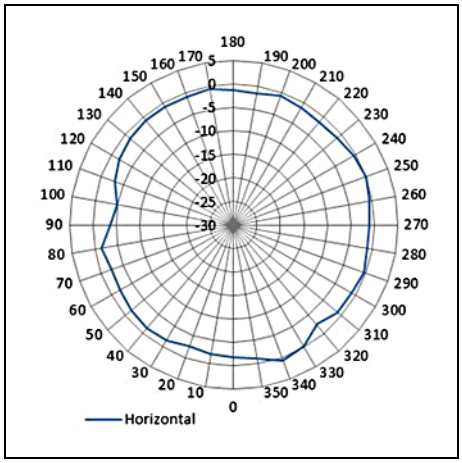
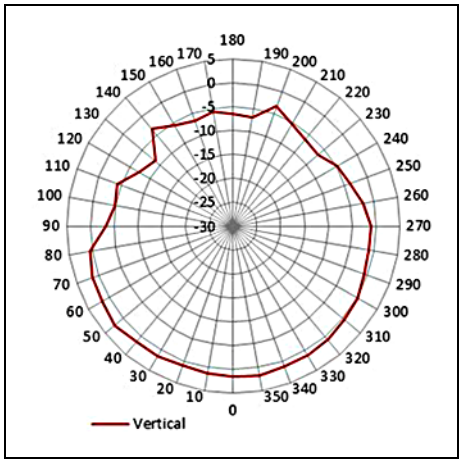
FAP-U421EV and U423EV require 25W (802.3at) static power supply. Customers that currently have 802.3af power will need to upgrade to 802.3at power. If the FAP-U detects an 802.3af power source, the radios will be disabled. The LAN1 and LAN2 ports are for uplink.

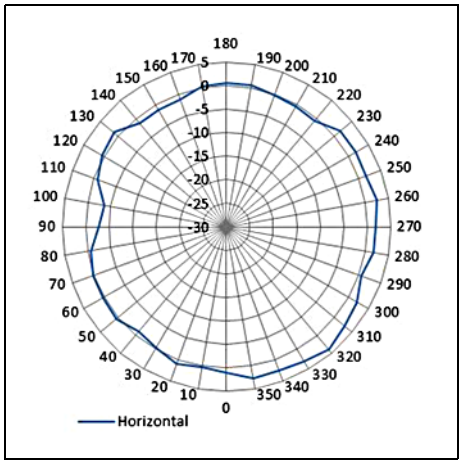
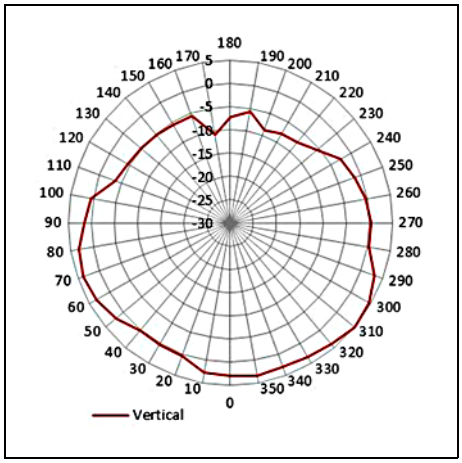
Mounting FAP

The FAP-U421EV has eight internal antennas. This AP can be mounted on the ceiling or a wall. The FAP-U421EV and U423EV both use same radio and enclosures, however, the FAP-U421EV uses internal antennas and the FAP-423EV uses external antennas. The FAP-U421EV uses FIPA omni directional antennas with 360 degrees Horizontal and greater than 120 degrees vertical beam width of coverage. With the 190-degree coverage pattern of the AP, an AP mounted on the ceiling would provide wide area coverage from the ceiling to the floor. Antenna coverage patterns must be considered when developing an AP placement plan.

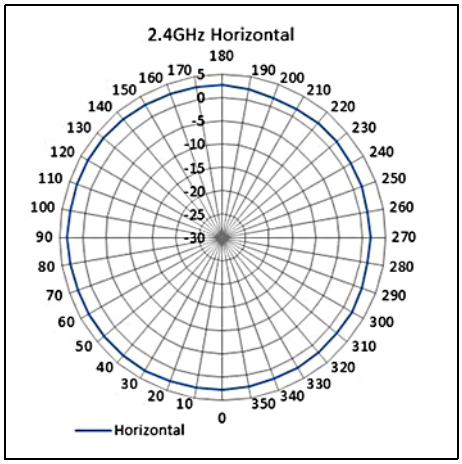
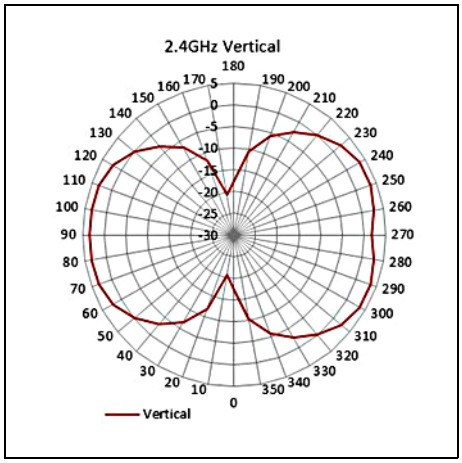
Antenna Radiation Patterns

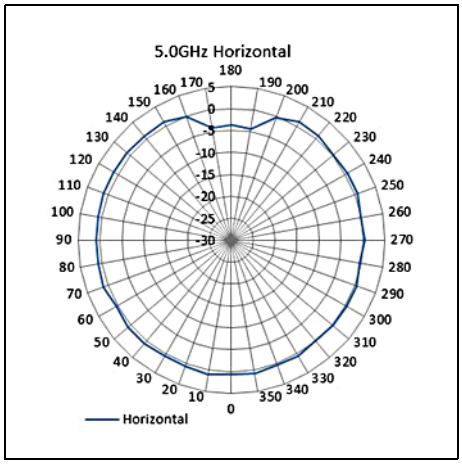
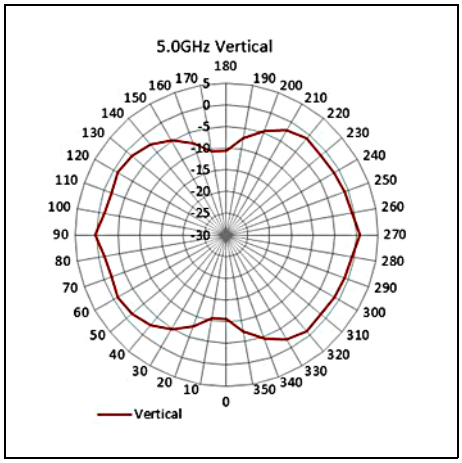
FAP-U421EV

Antenna	Radiation Pattern
2.4GHz Horizontal	
2.4GHz Vertical	

Antenna	Radiation Pattern
5GHz horizontal	
5GHz Vertical	

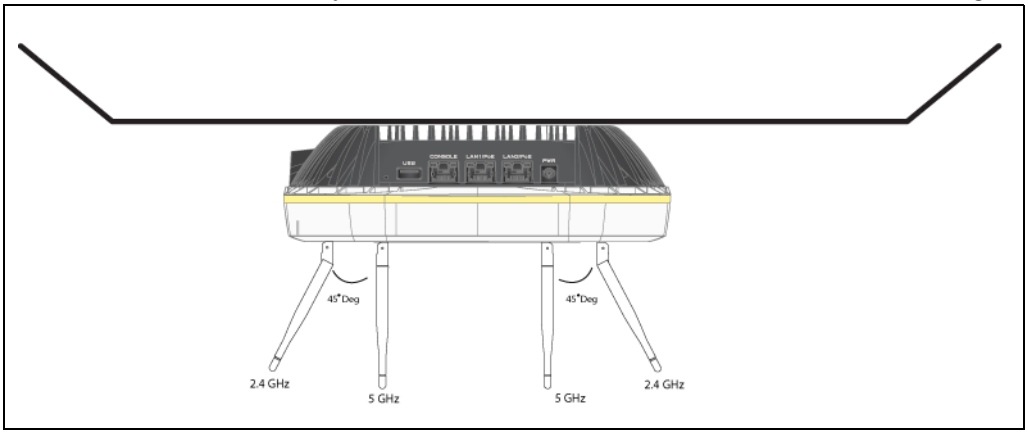
FAP-U423EV

Antenna/Plane	Radiation Pattern
2.4GHz Horizontal	
2.4GHz Vertical	

Antenna/Plane	Radiation Pattern
5GHz horizontal	
5GHz Vertical	

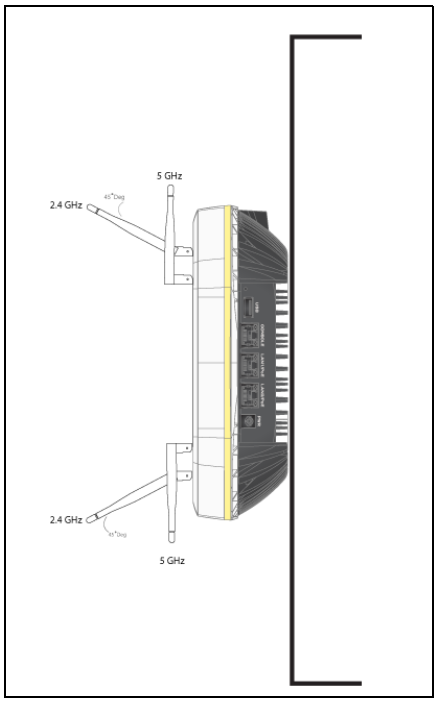
Ceiling Mount (FAP-U423EV)

All 5.0GHz antennas are vertically oriented and the 2.4GHz antennas are bent at 45 degrees.



Wall Mount (FAP-U423EV)

While mounting on walls, orient the 2.4GHz antennas at 45 degrees and 5.0 GHz antennas 0 degrees vertical.



Planning AP Location

It is a good practice to conduct a sitesurvey to assess coverage area and look for problem areas such as poor RF coverage or high retries. Fortinet enables customers to easily complete a sitesurvey right from within the FAP-U421EV or FAP-U423EV.

Sitesurvey

Fortinet sitesurvey is a simple tool that aids in network planning to find the right placement (mounting location) of APs such that clients connected to these APs receive high throughput, excellent coverage. To find the right placement of your AP, connect your Wi-Fi client to the AP that is in the sitesurvey mode and move around the deployment perimeter to identify areas that provide good connectivity (based on the results from the sitesurvey tool) to the Wi-Fi client. You can adjust the placement of the AP depending on the sitesurvey results.

FAP-U421EV and U423EV have built in mechanism to perform a sitesurvey of a 11ac network that provide you with true validation of AP placement and RF coverage. Some of the benefits of using the sitesurvey features include:

- Fast and easy way to validate 11ac design
- No controller required while taking measurements at different floors and locations in the building
- Surveys using laptop or tablet or mobile phone
- Easy-to-use web UI for setting up and measuring survey data
- Real time RSSI, S/N ratio, 802.11 Tx and Rx rates
- Simple 3-step process - connect, configure, and monitor

Using CLI

To get started with sitesurvey follow the simple procedure:

Enabling Sitesurvey

```
sitesurvey enable
```

This command enables the sitesurvey mode. The AP will reboot into sitesurvey mode and display the sitesurvey prompt.

```
ss > _
```

Disabling Sitesurvey

```
sitesurvey disable
```

This command disables the sitesurvey mode. AP will reboot into normal mode of operation.

Setting Country Code and Channel

```
sitesurvey countrycode set <country code>
```

By default the country code is set to US. When you set a country code, the first valid channel and the max supported Tx power for radio 0 and radio 1 for that country code is automatically set. To override the default channel for a country code, enter the `sitesurvey channel set <radio_index> <channel>` command.

Where,

- `radio_index` refers to the AP radios.
- Enter 1 for radio 1 (2.4 Ghz).
- Enter 2 for radio 2 (5Ghz).

To get the list of supported country codes, use the `ss countrycode help` command.

Setting Inactivity Time

```
sitesurvey inactivitytime <itime>
```

This command sets the time (in seconds) the AP will remain in the sitesurvey mode before a client associates with it. The time is specified in seconds and by default the AP will remain in the sitesurvey mode for 3600s. After the period of inactivity, the AP will reboot into normal AP mode.

Setting IP Address

```
sitesurvey ipconfig <ip_address> <netmask>
```

This command configures the sitesurvey AP with an IP address. You can use this IP address to access the sitesurvey GUI page via a browser. By default, the IP address and netmask are

```
set to 192.168.0.1 and 255.255.255.0.
```

Configuring SSID

```
sitesurvey ssid <radio_index> [<ssid>]
```

Where,

- `radio_index` can be 0, 1, or 3
- Enter 0 for radio 1 (2.4 Ghz)
- Enter 1 for radio 2 (5 Ghz)
- Enter 3 to specify SSID for both the radios

This command configures SSID for the specified radio. By default, SSID for radio 1 (2.4Ghz) is

```
set to Meru_Site_Survey_2.4 and SSID for radio 2 (5 Ghz) is set to
     Meru_Site_Survey_5.
```

Examples

```
ss > sitesurvey ssid 3
MERU_SITE_SURVEY SSID is assigned for both radio1 and radio2 as
     MERU_SITE_SURVEY
ss > sitesurvey ssid 1 <?]?] if SSID is not specified SSID is assigned
     to radio1
as MERU_SITE_SURVEY_2.4 by default
ss > sitesurvey ssid 2 <?]?] if SSID is not specified SSID is assigned
     to radio2
as MERU_SITE_SURVEY_5 by default
```

When using the GUI, the browser window will reset after 3600 seconds of inactivity, irrespective of the time set for inactivity. The browser refresh time cannot be changed.

```
ss > sitesurvey ssid 3 <?]?] if SSID is not specified
MERU_SITE_SURVEY_2.4 is assigned as SSID for radio1
```

MERU_SITE_SURVEY_5 is assigned as SSID for radio2.

After configuring SSID on AP radios, you can use the following command to selectively (per radio) enable or disable broadcasting SSID.

```
sitesurvey publishssid <radio_index> [on|off]
```

By default, SSID for both radios are broadcast.

Enable or Disable Radio

```
sitesurvey {radio | r} <radio_index> [on|off]
```

- Where,
- `radio_index` can be 0, 1, or 3
- Enter 0 for radio 1 (2.4 Ghz)
- Enter 1 for radio 2 (5 Ghz)
- Enter 3 for both the radios

This command enables or disables AP radio. Wi-fi clients connecting to the sitesurvey AP must use the same radio that is enabled in the AP. By default, both the radios are enabled.

Configure Sitesurvey Refresh Rate

```
sitesurvey statsrefrate [<rate>]
```

This command configures the time interval (specified in milliseconds) at which the AP will collect and send (display) sitesurvey results. By default, the refresh rate is set to 1000ms. The sitesurvey results can be viewed from the sitesurvey GUI page or the CLI.

Setting the Tx Power

```
sitesurvey txpwr set <radio_index> [<tx_power>]
```

Where,

- `radio_index` can be 0, 1, or 3
- Enter 0 for radio 1 (2.4 Ghz)
- Enter 1 for radio 2 (5 Ghz)
- Enter 3 for both the radios

Use this command to selectively set the transmit power for AP radios. By default, Tx power is set to maximum possible Tx power based on the country code, channel and the hardware capabilities. The `sitesurvey txpwr set 3` command (without the power value) will set the max Tx power supported for the selected country to both the radios.

Save Sitesurvey Configuration

```
sitesurvey save
```

After you have configured all sitesurvey options, enter this command to save your sitesurvey configuration. This command creates an ESSID with all configured parameters. Your Wi-Fi can now associate to this AP using the ESSID.

Using GUI

To access the sitesurvey GUI page, enter the IP address of the AP. If not previously set, enter the default IP address (192.168.0.1) of the AP. By default, the GUI page shows the sitesurvey results page. Click the Configure button to access the sitesurvey configuration options.

Parameters	Description
SSID Radio 0 SSID Radio 1	Enter a value that you will be broadcast for connecting your Wi-Fi client. The default values are Meru_Site_Survey_2.4 for Radio 0 and Meru_Site_Survey_5 for Radio 1.
Country	Select a country from this list. This selection automatically sets the first valid channel for each radio. However, you can choose to override them by selecting a different channel number.
Radio 2.4 Ghz Radio 5 Ghz	Select ON or OFF to enable or disable a radio.
Tx Power Radio 0 Tx Power Radio 1	Enter transmit power for each of the radios. Maximum value for Radio 0 (2.4 Ghz) and maximum value for Radio 1 (5 Ghz) is dependent on the selected country and the channel.
2.4 Ghz Channels 5 Ghz Channels	Select a valid channel. By default this is automatically set to the first valid channel for the selected country.
Publish SSID Radio 0 Publish SSID Radio 1	Select ON or OFF to broadcast SSID.

Parameters	Description
Stats Refresh Rate	Enter the time interval (in milliseconds) to collect and send (display) sitesurvey results.
Inactivity timeout period	Enter the time interval (in seconds) for the AP to wait for client to connect. After the inactivity time period, the AP will reboot to normal AP mode.

After configuring the above parameters click the Apply button to save the configuration.

Viewing Sitesurvey Results

Sitesurvey results can be viewed from CLI and using the GUI.

Using GUI

By default, the Sitesurvey page is displayed when you connect to the AP via browser. The Sitesurvey page among other pre-configured values displays key information about the connectivity experience of your Wi-Fi client.

The GUI page shows Sitesurvey results of only ONE client (the last connected client) connected to the AP. To view Sitesurvey results from all connected clients, use options from CLI.

About AP Location

The AP should be placed at a clear empty location on the Ceiling or side walls. Avoid mounting the AP near heavy metal objects such as refrigerator and microwave, which will block the radio waves, impact the antenna radiation patterns and interfere with the radio receiver.

AP Placement Plan

Developing an AP placement plan does not always require the use of a planning/survey tool such as Ekahau sitesurvey. There will be installations where placing 11ac APs every 50-100 feet (depending on the signal strength, client density, and throughput capacity requirements) will be sufficient. These simple installations are characterized by a uniform structure where it is relatively trivial to predict coverage patterns of 11ac APs.

When coverage planning is required due to highly irregular building designs, contractual agreement, or some other reason, the recommendation is to use the planning tools available in Ekahau Site Survey.

A post-AP-installation sitesurvey is generally recommended. The recommendation is to use a sitesurvey tool like Ekahau sitesurvey.

One-for-One AP Replacement

One question that is often asked related to migrating from non-11ac networks to 11ac networks is whether the network would work if a one-for-one swap is performed (i.e., replacing the 11n APs with 11ac APs). Assuming that the 11n network was designed to provide -65 dBm coverage or greater everywhere, the simple answer is yes. In addition, as mentioned previously, if the network is composed of mostly 11n clients, the network will likely perform even better with 11ac APs. Of course, the network will perform considerably better if the majority of clients are of

the 11ac variety; however, if the network is to be optimized to deliver optimal performance for 11ac clients, higher AP densities will be required (as compared to a typical 11n network).

AP Density

A good rule of thumb when determining the optimal 11n AP density, from the perspective of a station, is that a station, no matter where it is located, should be able to hear from 2 to 3 APs. This recommendation would still hold true for 11ac networks if the design called for approximately -65 dBm signal strength or greater everywhere; however, in order to support the highest data rates available in 11ac, higher AP densities will very likely be required. Higher AP densities will allow a client to hear more APs. Therefore, the recommendation for 11ac networks optimized for peak 11ac client performance is that clients should be able to hear from 3-5 APs.

Another consideration is that supporting 1024-QAM through a wall or some other signal attenuating obstruction is challenging, and therefore if you intend to optimize your network for 11ac performance, the recommendation is to put 11ac APs within line of sight of the intended coverage areas. Assuming line of site, 1024-QAM rates are achievable up to distances between 25 and 30 feet.

AP Transmit Power

With higher AP densities, there will likely be a need to reduce AP transmit power to lessen the negative effects of co-channel interference (CCI) and adjacent channel interference (ACI). This is true for high-AP-density Single Channel Architecture (SCA) networks as well as Multi Channel Architecture (MCA) networks.

2.4 GHz vs. 5 GHz Signal Strength

Thus far, all of the discussions regarding signal strength and AP density have been focused on 11ac radios. As was already mentioned, performing one-for-one AP replacements is a valid approach if the network design requirements for signal strength are roughly the same as they were for the existing network (e.g., -65 dBm or >). If this is the case, the 2.4 GHz network coverage and signal strength will be comparable to what existed prior to performing the one-for-one AP swap to 11ac APs. If, however, higher AP densities are required to meet higher signal strength requirements (e.g., -52 dBm or >), then there is a strong likelihood that the new network will be over-provisioned in the 2.4 GHz band. If this is the case, the recommendation is to provision some of the 2.4 GHz radios as full-time spectrum sensors, and/or configure some of the 2.4 GHz radios to 5 GHz radios and enable channel layer load balancing across the 11ac channel layers for high client density areas. It should be mentioned that certain restrictions apply with channel layer load balancing.

Migrating to Wave2 FAP

Migrating from Wave1 11ac AP

The general recommendation when migrating from wave1 AP to wave2 (FAP-U421EV/U423EV) is to proceed with one floor or section of a building at a time. This recommendation holds true for SCA (Single Channel Architecture) networks or MCA (Multi-Channel Architecture) networks, although the reasons behind these recommendations differ.

NOTE: It is also recommended that you increase the Tx power of FAPs to 20dBm after completing migration.

Migrating from 11abgn MCA Networks to 11ac MCA Networks

For MCA networks, if 11ac APs were mixed with 11abgn APs in an area, clients that are moving through this area may prefer an 11ac 80 MHz channel to an 11an 40 MHz channel. This could potentially cause some clients to stick to 11ac APs while ignoring 11n APs that may offer better service. Therefore, the recommendation is to migrate floor-by-floor or wing-by-wing to avoid mixing 11ac and non-11ac APs in the same area of a building.

Migrating from 11abgn SCA/VCell Networks to 11ac SCA/VCell Networks

For SCA (Single Channel Architecture) with VCell (Virtual Cell), it is recommended to avoid mixing AP model numbers for a given area, as VCell currently does not span across different AP model numbers. As with MCA (Multi Channel Architecture) networks, the general recommendation is to migrate floor-by-floor or wing-by-wing of a building.

At the border where 11ac APs are adjacent to 11abgn APs, there are a number of recommended techniques that can be used to prevent any issues related to VCell.

A border area could be the floor above or below, as well as a section or wing of a building that is adjacent to the area where a FAP has just been installed. The following configuration options would be recommended for 11ac AP and 11abgn AP border areas. Any one of the options listed below could be used to prevent VCell compatibility issues.

FAP-U421EV/U423s are configured to use different channels than the bordering non-AP832s.

Different ESS Profile Names are used for the FAP-U421EV/U423s and the bordering non-AP832s. (The same SSID can be used for both sets of APs.)

A different controller is used for each model of AP (11ac and non-11ac) and the controller index numbers are unique.

Again, just one of the three options listed above would be sufficient to satisfy the requirement when deploying SCA with VCell in areas where FAP-U421EV/U423s and non-FAP-U421EV/U423s are used.

Validating Coverage Post-Migration

Once the new FAP-U421EV/U423EV have been installed, channels have been selected, AP transmit power levels have been set, and so on, the recommendation is to do a thorough coverage survey throughout the entire deployment. The main goals here are to validate that the network is in fact providing the designed signal strength and SNR, and in the case of MCA

deployments, that there is a minimal amount of overlapping coverage for APs that are sharing the same channel. Ekahau's sitesurvey suite has tools that can perform this task, whether the network was built using SCA or MCA.

If it is determined that there are areas where coverage does not meet the requirements, AP transmit power can be adjusted; or if external antennas are used, they may need to be adjusted. In some cases, additional APs may need to be deployed. The validation/adjustment process should be iterative until all areas of the deployment have the coverage specified in the design requirements.

Network Tuning

It is highly unlikely that any initial Wi-Fi deployment will be optimally tuned, even if extreme care was taken during the planning and implementation phases, as there are too many variables to account for when dealing with Wi-Fi. Although it is beyond the scope of this guide to delve deeply into the art and science of Wi-Fi network tuning, this section will touch on a number of things that should be checked and, if applicable, adjusted.

There are a number of statistics that should be monitored post-deployment to determine how well the network is running, such as client counts per radio, channel utilization rates, radio retry rates, client data rates, application performance, SLAs met, etc.

Monitoring channel utilization rates, for example, can help identify where capacity needs may be high enough to warrant adding channel capacity. If adding more channel capacity is not the preferred option to increase throughput capacity, another option could be to upgrade clients from the existing 11n set to 11ac.

Network monitoring and tuning should be an ongoing activity, as RF environments, client mixes, application requirements, etc., tend to change over the course of the life of a Wi-Fi network.

Migrating in FortiWLM

In order to facilitate the FAP-U421EV/U423EV migration within FortiWLC (SD) and FortiWLM, a guide that describes the process to swap out APs has been created. Once the swap process has been performed on the controller, FAP-U421EV/U423EV automatically get updated in FortiWLM.